Astronomical Measurements in Ancient Greece (project TF2E)

Short Final report

Introduction – Project goals

Although it is not widely known to students and the public, the ancient Greek philosophers had made a number of accurate astronomical measurements and created successful models in an effort to describe the wonders of the Cosmos. With the power of the human mind they carried out reasonable estimates of the sizes of the earth, the moon and the sun and the distances of the sun and moon from the earth.

This project's aim is two-fold.

Firstly it aims at bringing this knowledge to the secondary education students, who, by carrying out these measurements, will appreciate how an innovative mind can explore the universe from our little planet. The students will carry on exploring the universe beyond the earth, moon and sun and by analysing their observations will evolve their knowledge of the universe and change any alternative ideas held to the scientific accepted ones.

Secondly, it is this project's aim to support these students in reaching out the community and spreading this knowledge to the public so that everyone can realize that the cosmos is not far out of reach but is within everybody's grasp to explore it even from their own backyard, as the Ancient Greek astronomers did.

1. Short summary

A series of workshops was designed to support students of the senior High School (called Lyceum) of Nea Zichni to get acquainted to the acomplishments of ancient Greek philosophers regarding astronomy. The students were taught according to this teaching-learning sequence and made measurements of the size of the Earth, the size and the distance of the Moon, and the size and the distance of the Sun. At the end of the spring term the participating students formed a report on the work they did in the project.

An 8-inch telescope was purchased with the appropriate accessories for observing the Moon, the Sun, the solar planets and other objects of the night sky and taking images of them. It was used by the students to observe sunspots during daytime and for other sky objects during nightime.

In the context of another environmental project, which also was carried out at our school, an excursion to the city of Kastoria was made, at which students from this project participated. A small portable telescope lent to us by the Center of Natural Sciences of Serres was carried there but during our stay in Kastoria heavy clouds were covering the sky not allowing for any descent observations.

Two short evaluation tests were constructed; one for measuring the students' conceptual evolution throughout the project and one for measuring the students' attitude towards astronomy. They were put together in a single looking test and were administered to the students at the beginning of the project (pre-test), at the end of the spring term as a mid-test and at the end of the fall term (post-test). The results were compared among the three instances to determine the successfulness of the project for the students of our school. This test is presented at the end of this report.

The participating students visited neighbouring schools and presented their work and experience with the project. They also raised interest for astronomy inside our school by

presenting their work to the rest of our school students, too. The same evaluation tests were also completed by students of all these schools before and after our students' presentation to check for either an increase in field knowledge understanding or attitude change towards astronomy. The students' answers were processed and the results are presented in section 3.

A web site has been created for the project which presents the objectives, the events and other information relevant to the project. The address of the site is

http://lyk-n-zichn.ser.sch.gr/ADMire

and the site was constantly updated and enriched with new material as the project evolved.

The project participated in the summer festivities of the local municipality by organizing an open astronomy evening. During the event, which took place on 16th July, Asst. professor K. Tsiganis gave an invited talk, our school students' work was presented to the public and a local amateur club called Astropili provided telescopes, which, together with our school telescope guided people from the local community to the wonders of the Universe. The event was a great success and will be repeated every summer and on other possible occasions.

Our telescope was equipped with a secondary guiding system to lock upon stars and provide stable guidance to the telescope, necessary for carrying out astrophotography. This allowed our students to take pictures of constellations and deep sky objects during the fall term. An introduction to the standard data reduction techniques was also given on using bias, dark and flat frames. The best images of our student efforts on some night sky objects are published at the project's website.

2. Reaching our goals

The first goal of the project was accomplished by incorporating the project in the context of the Spring Term course of the Greek curriculum called "Project". Within this course 19 students learned the fundamental elements of earth and sky motion and attempts were made to restore any misconceptions inherited by their surroundings. Measurements of the sizes of the Earth, Moon and Sun and their distances were carried out and observations of the sun at normal class hours and sky observations at evening sessions were made.

To evaluate the students' field knowledge evolution as well as to check for attitude changes two short tests were constructed. They were put together in a single looking test and were administered to the participating students at the beginning of the project (pre-test), at the end of the spring term as a mid-test and at the end of the fall term (post-test). This test is presented in the end of this report.

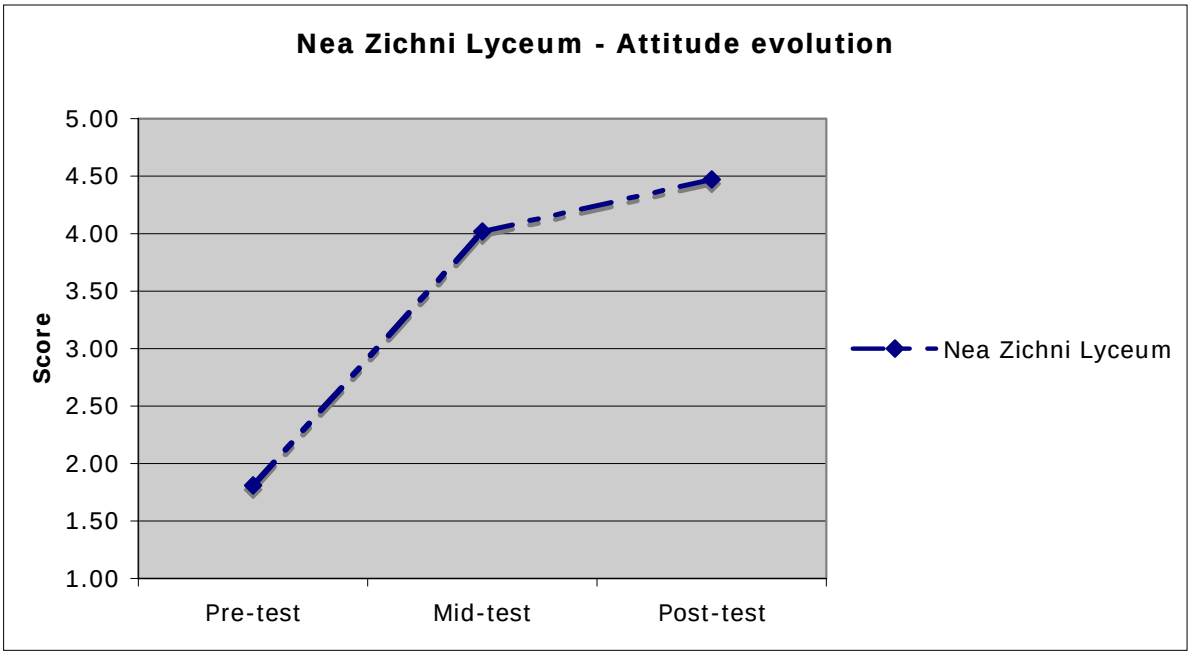
The first five questions were testing the students' attitude towards astronomy. A five level rubric was used to score the answers to these questions. Each answer received score points equal to the level of the rubric indicated by the student, namely 1, 2, 3, 4 or 5. Since in the last three questions of this test the highest score was showing a high dislike for astronomy, these three question scores were reversed for the final calculation of the score of the students in the attitude test.

The remaining eight questions were testing the field knowledge of the students in the specific areas which were discussed within the context of this project. Each answer was evaluated independently by two teachers and rated from 0 to 1 according to the correctness and completeness of the answer. This scale was composed of eleven levels, namely 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.

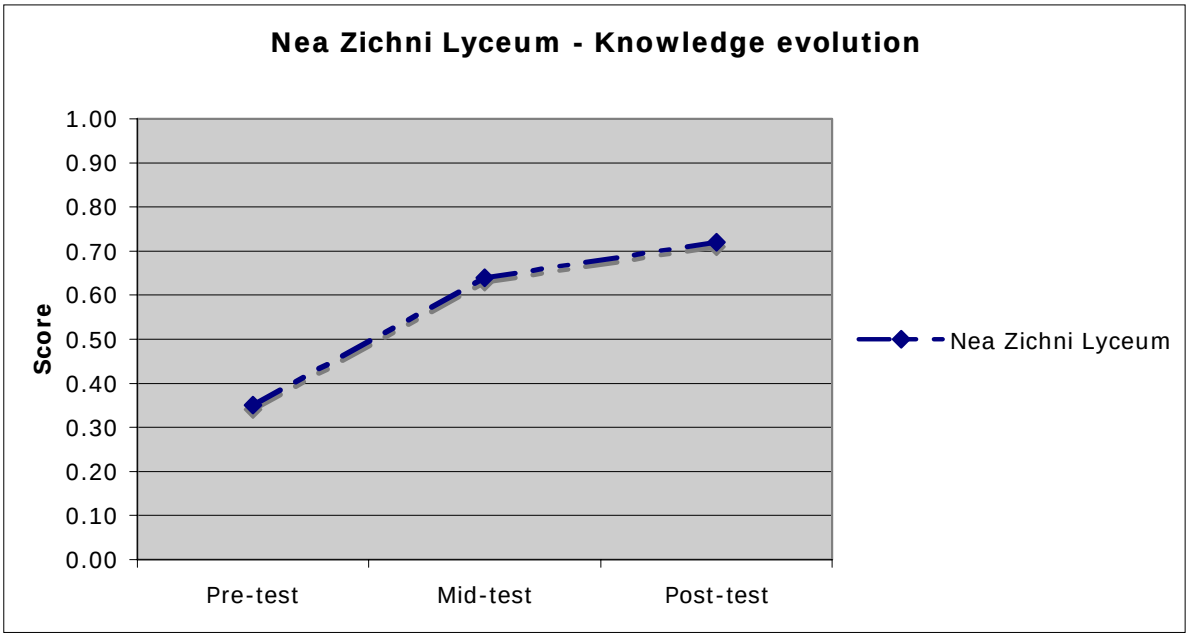
The students' scores were averaged for every test instance and were compared among the three instances to determine the successfulness of the project for the students of our school who participated in the project. The average students' scores are shown in the following table and are graphically represented in Pictures 1 and 2.

Nea Zichni Lyceum	Pre test	Mid test	Post test
Attitude	1.81	4.02	4.47
Field knowledge	0.35	0.64	0.72

Table 1. Average student scores for the participating students of Nea Zichni Lyceum



Picture 1. The participating students' attitude evolution throughout the project



Picture 2. The participating students' field knowledge evolution throughout the project

A significant improvement is observed in both the students' attitude towards astronomy and their relevant field knowledge throughout the whole project duration. This improvement is also verified by a statistical analysis through paired samples t-tests comparing pre- and mid-test scores, mid- and post-test scores and pre- and post-test scores. All tests show that the case for no improvement in any comparison can be rejected with greater than 99% confidence.

The improvement seems to be great in the first part of the project (from pre-test to mid-test) and quite small in the second part (from mid-test to post-test), as can be shown from the above graphs. This can be attributed to the fact that the initial scores in the pre-test were low, allowing for a great improvement afterwards, whereas the mid-test scores were above the middle point of the corresponding scales allowing for only modest improvements. To correct for this effect and better assess the improvement on both parts of the project we calculated the so-called Hake gain for both the attitude and field knowledge improvement in mid and post-tests. The Hake gain is defined as the normal gain divided by the maximum gain which can be achieved in each case:

Hake gain = (final score – initial score) / (maximum score – initial score) X 100%

and the average Hake gains for both the attitude and field knowledge tests are shown in table 2.

Nea Zichni Lyceum	Pre test to Mid test Hake gain (%)	Mid test to Post test Hake gain (%)	Pre test to Post test Hake gain (%)
Attitude	69.28	45.92	83.39
Field knowledge	44.62	22.22	56.92

Table 2. Hake gains for the participating students of Nea Zichni Lyceum

In essence, Hake gain shows the percentage of students who changed attitude towards astronomy or corrected their initial knowledge about astronomy during the project. Hake gains below 30% are considered to be small , between 30% and 60% are considered to be of medium level to significant and above 60% are considered to be very significant.

As can be seen from the above table, there is a very significant total attitude improvement towards astronomy throughout the whole project. This improvement was mostly accomplished in the first part, but also appeared during the second part. This is expected since the excitement produced by the initial contact with a subject such as astronomy is likely to drive an initial wave of positive attitude towards astronomy. This attitude improvement will then decline but will remain present as students gain a better understanding of the subject and get engaged in challenging activities, like astrophotography.

A similar trend is also observed in the field knowledge evolution: there is a greater improvement in the first part of the project and a smaller one in the second part. This is expected since there was no new knowledge offered to the students in the second part and the improvement can only be attributed to the fact that the students used some of their knowledge again and thus acquired a better understanding.

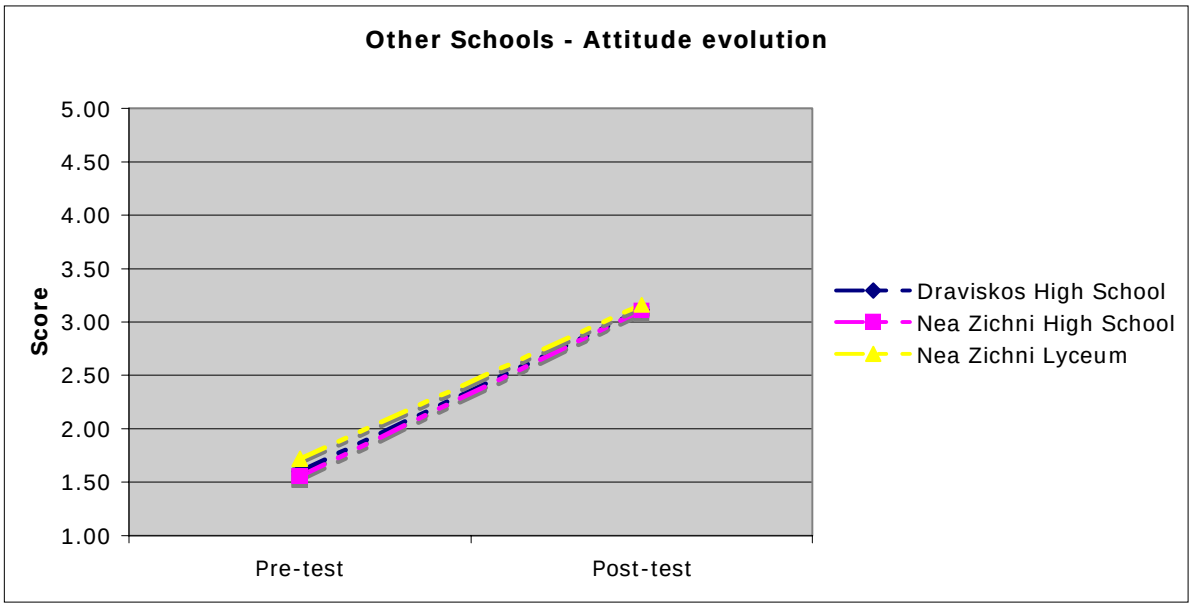
The second aim was accomplished by supporting the participating students along with invited university experts to present their techniques and findings at a series of public lectures to the students of the other schools of the district and the local community during the local cultural festivities in the summer of 2013. The participating students presented their work to the rest of the students in their class, students of the Draviskos High School and students if the Nea Zichni high School. All these students completed the same

attitude and field knowledge test before and after the presentation and their answers were scored as described above.

These students' scores were averaged for every test instance and were compared among the two instances to determine the successfulness of the project for the students of our school who did not participate in the project and the students of the other two schools. The average students' scores are summarized in the following table and are graphically represented in Pictures 3 and 4.

	Pre test	Post test
Nea Zichni Lyceum		
Attitude	1.72	3.16
Field knowledge	0.31	0.40
Draviskos High School		
Attitude	1.60	3.11
Field knowledge	0.26	0.34
Nea Zichni High School		
Attitude	1.56	3.10
Field knowledge	0.23	0.31

Table 2. Average student scores for the non-participating students of Nea Zichni Lyceum and the students of the Draviskos and Nea Zichni High Schools

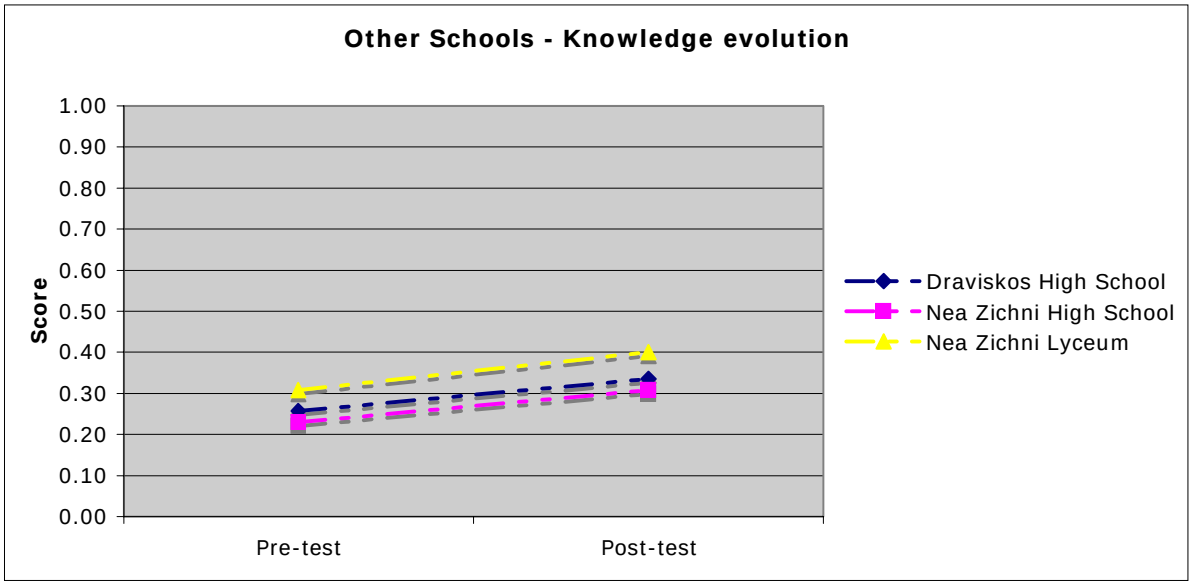


Picture 3. Attitude evolution of students not participating in the project

It is evident from these results that there exists a significant improvement in the attitude towards astronomy of all students exposed even briefly through one lecture to astronomy. This improvement is also verified through a statistical analysis of the students scores with a paired samples t-test from pre to post-test for all three schools at the 99% confidence level. The corresponding Hake gains are shown in Table 3.

The field knowledge evolution does now show such an improvement. This is expected since there was only one lecture fiven to them by our students. A statistical analysis with paired samples t-tests, however, reveals that this very small improvement is real at a significance level of 99%. This is attributes to the fact that most of the students showed a small but steady improvement of their test scores with very few decreases, which

statistically yields an effect with high confidence. The corresponding Hake gains for the field knowledge evolution are also shown in Table 3.



Picture 4. Field knowledge evolution of students not participating in the project

	Pre- to post- test Hake gains
Nea Zichni Lyceum	
Attitude	0.44
Field knowledge	0.13
Draviskos High School	
Attitude	0.44
Field knowledge	0.11
Nea Zichni High School	
Attitude	0.45
Field knowledge	0.10

Table 3. Hake gains of students not participating in the project

Overall the above results show a remarkable success of the project in raising the students' interest and knowledge in astronomy. In particular, the students were stimulated in getting engaged in scientific activities related to astronomy and observing and taking pictures of sky objects through a telescope. This resulted in a increase in their interest about astronomy and subsequently in an increase in their related field knowledge. This is also evident from the students' small essays about their experience with the project, which are published in the project's web site. Furthermore, this excitement was also passed to the local community through the students' families (a couple of citizens owing telescopes contacted the school in an effort to organize more observing nights) and through the presentation of the students' work in the local summer festivities.

3, 4 and 5. Deviations and challenges. Recommendations for improving the impact of the project

The original planning for the project was closely followed with no deviations during implementation. The students participated promptly and were very excited to be part of the

project. This made the implementation easy and no significant problems were faced. The greatest challenge was to get the students to present their work to other students and the rest of the local community. This proved only partially successful since the participating students did make their presentations to other students in our school and other high schools, but did not present the project themselves publicly in front of the rest of the community in the astronomy day in the summer festivities. This was finally presented to the public by the coordinator of the project with the students being among the audience.

A restriction of this project is that it dealt with only a very small part of astronomy and the participating students were only partly exposed to the astronomical knowledge. A more systematic approach, with a regular astronomy course and hands-on activities with the telescope both at class hours and at evening sessions would greatly enhance the students' acquired knowledge and their abilities to carry out observations. There are plans to connect the school computer laboratory with the telescope so that it can be placed at the roof of the building and people from inside the school can remotely access it and observe sky objects without climbing on the roof of the school at night (only positioning of the telescope is currently supported with remote operation of camera and CCD but without any remote focus support). Furthermore, if the above approach is applied to high school students, who are not as heavily burdened with classes as Lyceum students, and can work on astronomy for 4-5 years before leaving school to enter university, stable groups of students can be formed which can act as bright active nuclei attracting others to the group. Unfortunately the students who participated in this project were already in the second grade of Lyceum during the school year 2012-2013 and this school year (2013-14) are very busy preparing themselves for the pan-Hellenic exams for entering the university. For this reason, students from the first grade of our school also participated in astrophotography, in the last part of the project in the fall term.

Despite these deficiencies, the project was very successful and accomplished all its goals, as was discussed in the previous section of this report. It is due to this success that activities of this project will continue to be implemented in the following years, like earth radius measurements, evening sky observations and astrophotography and summer astronomy nights, even without having any formal obligation. Furthermore, the cooperation with neighboring high schools will be tightened in all the above activities with the aim to form groups of students actively interested in astronomy. Cooperation will also be strengthened with Astropili, a club of amateur astronomers in Serres, who are trying to raise interest for astronomy among the students of the Technological Education Institute of Serres and the citizens of the city along with the local UNESCO branch.

6. Recommendations for expanding the project

As mentioned above, although the project formally reached completion at the end of 2013, it will be continued over the next years with other students coming to the Nea Zichni Lyceum. It will also be expanded to the neighboring high school students through cooperation with physics teachers of these schools and equipment sharing so that students will appreciate the beauty of astronomy sooner and will be more actively involved in astronomical activities.

At a later stage perhaps a local network of schools and other groups of people interested in astronomy, like Astropili, could be formed, which can coordinate astronomical events and facilitate equipment sharing throughout the whole county of Serres. A web site containing astronomical information on objects, techniques and events, providing access to services like equipment sharing or remote observing and facilitating communication between

members of the astronomy network could act as the link bringing together all those people interested in astronomy and promoting astronomy development locally.

Such a web portal could also act as a link in uniting other similar efforts thoughout the globe and facilitate communication among groups which can thus become parts of an international network of schools, universities, research organizations and various groups promoting the development of astronomy worldwide. The OAD can be a vital part of this network, which can initially be formed by the groups which have been supported so far in implementing astronomy oriented projects. This international network would mostly facilitate the exchange of information (scientific, technical, observational, computational etc), the implementation of remote observations through the use of remotely operated fully automated telescopes, the mobility of people through visitor exchange programs and cooperation among people from all over the world in carrying out international projects, such as measuring the earth radius by doing simultaneous object shadow measurements in varius places on the earth.

7. Project resources

Materials produced specifically for this project and used throughout this project include the worksheet used by the students to carry out and complete their measurements, the test administered to the students to evaluate their attitude towards astronomy and their field knowledge in the areas addressed by this project and the presentations created by the students to disseminate their work. All this material along with short statements in English from the students about their experience with the project, photographs of students at work, astronomical objects photos taken by the students (Sun, planets, stars, constellations, deep sky objects) and other information is available in the project's website at the address

http://lyk-n-zichn.ser.sch.gr/ADMire

Acknowledgements

All the students and the teachers participating in this project would like to thank the Office of Astronomy for Development (OAD) of the International Astronomical Union (IAU) and especially Kevin Govender and J.C. Mauduit for their financial and moral support in realizing this project and letting us experience this journey to our Universe over the past year. Be assured that we will continue to frequently visit the skies through the window you've helped us open to the Cosmos.